Supplemental Material: Limitations of Remotely-sensed Aerosol as a Spatial Proxy for Fine Particulate Matter

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## S1   Exploratory analysis results based on monthly values

Here we consider spatial associations of monthly average PM and AOD, matched in space, for each of the 12 months of 2004, to supplement the daily and yearly analyses in the main paper. We focus on MODIS and GOES because of the extremely low retrieval availability of MISR, which would require interpolation of AOD values over very large areas with no retrievals.

Even after averaging to the month, some locations have no retrievals, so we use a statistical smoothing model to estimate an AOD surface for each month, using a computationally efficient Markov random field representation of a thin-plate spline (Rue and Held 2005, Sec. 3.4.2; Yue and Speckman, unpublished manuscript) that readily fits the AOD retrieval data for each month (there are as many as 15,000 observations in a month). We use a heteroscedastic residual variance that accounts for the differing number of retrievals in different locations. While the model has the flexibility to do either substantial or little smoothing, in practice because the AOD values are fairly smooth at a fine spatial scale, the smoothed fields look similar to the raw fields, but with imputed values where no data are available.

Correlations are higher in the warmer months, but are moderate at best (Supplemental Material, Figure 1). Results are similar when restricting to locations with at least three days with AOD retrievals in a given month. The poor correlations result in part because of the limited retrieval availability, particularly during winter, seen in red in Supplemental Material, Figure 1.

Taking the twelve smoothed monthly values and averaging to the year at each location, Supplemental Material, Table 1 shows near-zero correlations of raw AOD and moderate correlations for calibrated AOD

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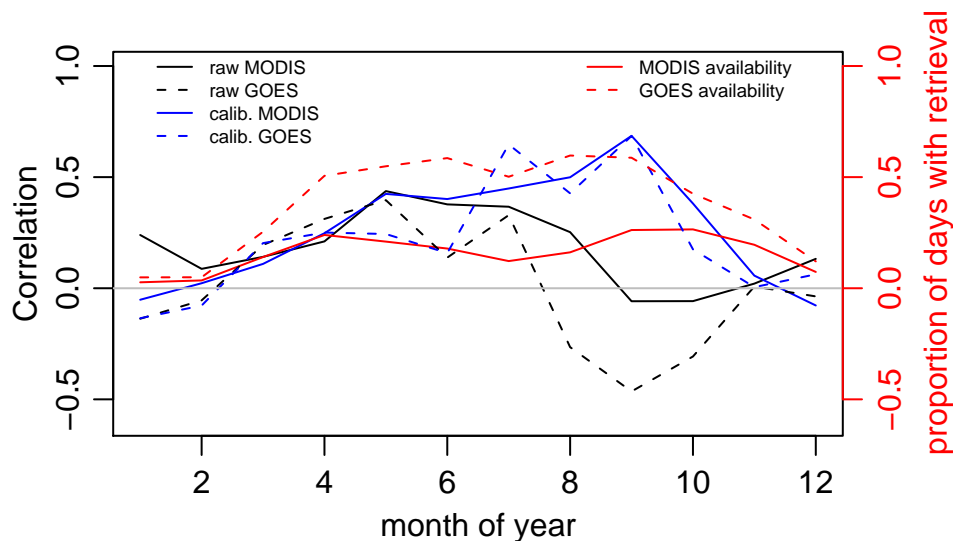
Supplemental Material, Figure 1: Correlations (across space) of monthly average smoothed AOD with spatially-matched PM by month for the mid-Atlantic focal region for locations with at least 5 daily PM values in the month (black for raw AOD and blue for calibrated AOD). Red lines show the proportion of days with a successful retrieval by month, averaged over non-water areas in the region. For consistency, results exclude the site excluded in Table 1 in the main paper, but this exclusion has little effect here.

with yearly average PM. By averaging with equal weights for each month, we attempt to account for the differing retrieval availability in different seasons. Focusing on the warm season, to avoid months with few retrievals, correlations of calibrated AOD increase but those of raw AOD do not. If we consider only monitors with at least 300 observations (i.e., monitors reporting daily with little missing data), correlations for the calibrated AOD are similar, while for raw AOD, they are higher but still moderate in magnitude. The increased correlations may be related to the fact that daily monitors are more likely to be in locations with high PM concentrations; daily monitors are more likely to be categorized by EPA as monitors sited to monitor high concentration areas (18% of daily monitors but only 5% of non-daily monitors).

Supplemental Material, Table 1: Correlations (across space) of yearly and warm-season (April-October) average AOD and spatially-matched PM (sites with at least 100 daily PM observations) for the mid-Atlantic focal region. Averages are computed by averaging over monthly values; for AOD these are produced by spatial smoothing of the available monthly data, thereby filling in missing values at the monthly level. Results exclude the site excluded in Table 1 in the main paper.

	Raw AOD		Calibrated AOD	
	MODIS	GOES	MODIS	GOES
Overall correlation	0.19	-0.06	0.53	0.44
Correlation for April-October	0.05	-0.19	0.65	0.70
Overall correlation, daily monitors	0.43	0.27	0.45	0.40

References

Rue H, Held L. 2005. Gaussian Markov Random Fields: Theory and Applications. Boca Raton: Chapman & Hall.